CO_2 supply from the North Sea and the Baltic Sea to the North Atlantic Ocean – evidence for the continental shelf pump

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Coastal and marginal seas are thought to act as a continental shelf pump transporting CO_2 from the atmosphere to the open oceans. The CO_2 uptake in coastal seas is triggered by high biological activity increasing the CO2 concentrations of their waters which finally are transported to the open ocean. The North Sea and Baltic Sea located in north-west Europe are connected via the Skagerrak where the Baltic Sea water first enters the North Sea. The North Sea the provides then link to the North Atlantic Ocean. Carbon budgets for the Baltic Sea and the North Sea will be presented in order to provide evidence that in both seas the transfer of CO_2, i.e. the continental shelf pump, acts in two different, but characteristic pattern.

The Baltic Sea as a brackish water system collects river water and one might even call it as an estuarine system in a broader sense. Two major drainage areas provide the fresh water supply to the Baltic Sea: The Scandinavian shield supply CO_2 –poor waters and the north-east European continent CO_2 –rich waters. During the transport of Baltic Sea water to the North Sea the CO_2 concentrations increase continuously. Riverine inputs in part control primary production in the Baltic Sea, however the major control mechanism is the winter nutrient concentrations. These are established by an interaction of production, remineralisation, export and riverine and atmospheric inputs on decadal time scale because of the residence time of the Baltic Sea water of approximately 25years. The Baltic Sea thus acts as a continental shelf pump for atmospheric CO_2 which injects CO_2-rich water to the Atlantic Ocean (injection pump).

In contrast the North Sea water is renewed once to twice per year most notably by water from the North Atlantic Ocean. The major control mechanism of the biological activity in the North Sea are thus the continuous (and - in comparison to the Baltic Sea - high) nutrient inputs for the North Atlantic Ocean. For the CO_2 export from the North Sea to the Atlantic Ocean this means that the water is enriched by CO_2 during its 6-12 month travel through the North Sea. Having in mind that almost no burial occurs in the North Sea, the North Sea acts as a continental shelf pump for atmospheric CO_2 by increasing the CO_2 concentrations in the Atlantic waters while they are bypassing through the North Sea (bypass-pump).